

CLAIMS

1. A process for the production of submicron particles comprising the steps of :-
 - (i) placing first and second electrodes in a volume of coolant, the electrodes being mutually spaced,
 - (ii) passing an electrical current across the electrodes whereby to generate an electrical arc therebetween,
 - (iii) maintaining a stable arc by controlling the relative spacing between the two electrodes to melt or evaporate and separate material from at least one of the electrodes such that droplets of said material are formed, and
 - (iv) quenching said droplets to form said submicron particles of the material in the coolant.
2. The method of claim 1, wherein the electrodes are initially in contact when the electrical current is passed through them, the arc of step (ii) being created by moving them apart.
3. The method of claim 1 or 2, wherein the electrodes used in the method are made from materials selected from metals, metal alloys, graphite carbides, nitrides, oxides, noble metals, amorphous compositions and metal hydrides.
4. The method of claim 3, wherein the metal is selected from one or more of iron, tungsten, aluminium, titanium, magnesium and nickel, the metal alloy is selected from one or more of low carbon steel, cast iron, TiAl, Ti-6Al-4V, stainless steel, tool steel, Fe-Ni-Co-Cr-Mo, Al-Cu-Fe-Mg-Si, Ni-Co-Cr-Fe-W, Cu-Ni, Cu-Sn, Mg-Al-Mn-Si and Co-Cr-Ni-Fe-Mo-W, the carbide is selected from one or more of SiC and WC, the nitride is selected from one or more of TiN, AlN and Si₃N₄, the oxide is selected from one or more of PbTiO₃, TiO₂ and SnO₂, the noble

metal is selected from one or more of Au, Pt and Ag, the amorphous composition is selected from one or more of Au-Ge, Co-Fe-B-Si-B-Mo, and Zr-Al-Ni-Cu, and the metal hydride is MgH_2 .

5. The method of any preceding claim, wherein one or both electrodes are bilayer or multilayer.
6. The method of claim 5, wherein the or each bilayer electrode is made up of an outer layer of graphite and an inner core of Fe or an outer layer of tin or copper and an inner core of aluminium or iron.
7. The method of claim 5, wherein the or each multilayer electrode is made up of alternate layers of Fe and Cu.
8. The method of any preceding claim, wherein the coolant is maintained at a temperature of less than 200 K.
9. The method of any preceding claim, wherein the coolant is liquid nitrogen or liquid argon.
10. The method of any preceding claim, wherein a quantity of reactant is mixed with an essentially inert coolant such that the material melted/evaporated in step (iii) reacts with the reactant prior to being quenched in step (iv).
11. The method of any preceding claim, wherein a quantity of solvent is introduced into the coolant after step (iv) so as to protect the submicron particles after the removal of the coolant for collection.

12. The method of claim 11, wherein a small quantity of surfactant is introduced into the coolant prior to step (iii) or after the solvent addition to prevent agglomeration of the submicron particles.
13. The method of any preceding claim, wherein during step (iii), a flow of coolant is introduced into the spacing between the electrodes whereby to displace droplets out of the hot zone of the arc.
14. The method of any preceding claim, wherein step (iii) is achieved by moving, preferably continuously, one of the electrodes relative to the other as material is melted/evaporated.
15. The method of any preceding claim, wherein during step (iii), relative rotation is induced between the electrodes whereby to promote separation of the material from the electrode.
16. The method of any preceding claim, wherein said process is a batch process, the particles being recovered after removal of the coolant.
17. The method of any one of claims 1 to 15, wherein the process is continuous, the method including a step of continuously passing coolant over the electrodes.
18. The method of claim 17, wherein the particles are separated from the coolant after passing over the electrodes and the coolant is recycled back over the electrodes in a continuous circuit.
19. A process for depositing a coating on a substrate comprising the steps of:-
(i) placing first and second electrodes in a volume of coolant, the electrodes being mutually spaced,

- (ii) passing an electrical current across the electrodes whereby to generate an electrical arc therebetween, and
- (iii) forming a coating on one of the electrodes which serves as the substrate, said coating being at least partly derived from said coolant.

20. The method of claim 19, wherein the coolant is liquid nitrogen, an organic solvent or an aqueous based liquid, the process resulting in a nitrogen-based, a carbon-based or oxide-based coating respectfully.

21. The method of claim 19 or 20, wherein the coating formed in step (iii) is at least 1 μm thick.

22. The method of any one of claims 19 to 21, wherein the electrode serving as the substrate is continuously moved relative to the other electrode, whereby to form a continuous coating on the substrate electrode.

23. The method of any one of claims 19 to 21, wherein the electrode serving as the substrate is maintained stationary and is surrounded by the other electrode at a given spacing, whereby to provide a continuous coating on the substrate electrode in a single step operation.

24. An apparatus for the production of submicron particles and/or for depositing a coating on a substrate, said apparatus comprising:-

- (i) a sealable container for coolant,
- (ii) an anode and a cathode mounted within the container,
- (iii) power supply means for passing a current between the anode and cathode, and
- (iv) adjustment means operably connected with at least one of the anode and cathode for controlling the spacing therebetween.

25. An apparatus as claimed in claim 24, wherein the anode/cathode combination is selected from graphite-graphite, graphite-steel, tungsten-steel, tungsten-cast iron, tungsten-aluminium or aluminium alloy, tungsten-copper, tungsten-nickel, tungsten-iron, tungsten-gold, tungsten-titanium, tungsten-magnesium and tungsten-stainless steel.

26. The method of claim 24 or 25, wherein the anode and/or cathode comprises more than one material, such that, in use, generation of heat by the arc discharge causes the materials to react before solidification or condensation.

27. The method as claimed in claim 26, wherein the anode and/or cathode may comprise bi-layer or multilayer structures of different materials, such that the layer structures are maintained in the submicron particles formed at the end of the process..

28. The method of any one of claims 24 to 27, wherein a supporting frame is provided for the anode, cathode and adjustment means; which components together with the supporting frame constitute an assembly which is removable from the container.

29. The method of any one of claims 24 to 28, wherein the adjustment means comprises a rod connected to one of the anode and cathode, preferably the anode, the rod extending to the anode or cathode through a wall of the container.

30. The method as claimed in claim 29, wherein the rod is screw-threadingly engaged with the wall of the container.

31. The method of any one of claims 24 to 30, wherein sensing means is provided, the adjustment means and sensing means being operably connected such that in use, the adjustment means is automatically adjusted according to the output of the sensing means.

32. The method as claimed in claim 31, wherein the sensing means comprises a voltmeter for monitoring the voltage across the anode and cathode, or temperature sensing means to monitor the temperature of the arc.

33. The method as claimed in claim 32, wherein a spectrometer is used to indirectly measure temperature by monitoring the intensity or wavelength of light produced by the arc.

34. The method of any one of claims 24 to 33, wherein the container is provided with an inlet and an outlet for coolant, a coolant return circuit being provided between the outlet and the inlet and a powder recovery region being provided downstream of the container.

35. The method of any one of claims 24 to 33, wherein the container is provided with a powder recovery region, such as a collector plate located at the base or on the wall of the container.